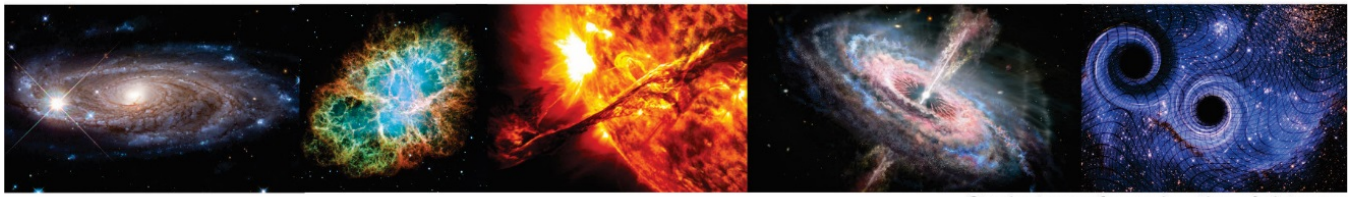
Astronomy 101 / Physics & Astronomy Department

Stars, Galaxies & the Universe

Spring Semester 2021 / Syllabus



See last page for explanation of pictures

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Webpage: http://ehl.web.rice.edu (link to course site & syllabus)
Office Hours: Flexible by arrangement/appointment

This course is intended to satisfy a Group III distribution requirement. Students seeking to accumulate credit toward fulfilling a major in astronomy/astrophysics should consider alternatives -- such as ASTR-350/Introduction to Astrophysics-Stars or 470/Solar System Physics -- that provide credit toward the major degree . . . though they are welcome here as well.

Tuesdays & Thursdays: 3:10 - 4:30 pm / Remote Online
Teaching Assistant: Cody Meng <cxm2@rice.edu>

Because of the pandemic, this course is currently offered remotely online, both for students attending Rice locally at the campus and for students who are attending Rice remotely.

SYNCHRONOUS ATTENDANCE through live-online scheduled class sessions on *Zoom* [Tuesdays & Thursdays, 3:10 - 4:30 pm, U.S. Central (i.e., Rice-Campus) Time] is preferred, and encouraged of all students for whom it is feasible.

Recordings of class sessions will also be made available asynchronously, posted on CANVAS.

ASYNCHRONOUS ATTENDANCE will be enabled through class-session recordings posted on CANVAS.

Assignments will be distributed & collected through the CANVAS website. Preferred formats (when applicable) will be *PDF* or *Word*. Additional information will be made available as the class starts up.

Those away from the campus may lack ready access to some desirable infrastructure. In that event, it is important to let me know as early as possible so that we can clarify any needed adjustments.

Course Objectives

The observable Universe seems to have originated about 13.8 billion years ago in an event we call the *Big Bang*. In the immediate aftermath of the Big Bang, the visible matter in the Universe consisted almost entirely of hydrogen and helium, and contained virtually none of the other material essential to the existence of ourselves or our environment. Now, 13.8 billion years later, we inhabit a small, rocky, damp planet, orbiting an ordinary, otherwise undistinguished star we call the Sun, in an otherwise obscure region of a galaxy we call the *Milky Way*. The Milky Way galaxy contains more than 100 billion stars, some larger than the Sun, some smaller, some older, some younger. The part of the Universe we can see contains an estimated 100 billion other galaxies -- some larger with more stars than the Milky Way, some smaller with fewer stars. The Sun and Earth are moderate late-comers in the Universe, having formed about 4½ billion years ago along with seven other surviving planets. We

call this system of the Sun with its associated planets the *Solar System*. By the time the Solar System formed, the Universe had already evolved through two-thirds of its current age. So far as we know, the Solar System -- as important as it is to us -- is neither unique nor special in the Universe and occupies no special position.

The evidence indicates that life has been present on Earth throughout most of our planet's existence, apparently having started between 3½ and 4 billion years ago. For almost all of Earth's history, terrestrial life consisted entirely of microbes. During the most recent billion or so years, multicellular life evolved from symbiotic colonies of those microbes. Only very recently, during the past several million years, have we humans -- possessing the most adept combination of cognitive and manipulative capabilities of any species on our planet -- evolved from those cosmic antecedents. The total time during which we terrestrial humans and our most immediate ancestor species have existed spans a mere one-tenth of one percent of the age of Earth, and about one-thirtieth of one percent the imputed age of the Universe.

This course explores our understanding of the Universe, the objects, systems and events that constitute the universe, important physical processes that control how these objects and systems behave, the nature and behavior of matter and energy, and how matter and energy interact to shape the behavior, evolution and formation of astrophysical systems. We emphasize how the known facts and laws of nature -- including the forces, laws of motion, and the structure of matter -- work to shape and control our world and help us to understand what we see and experience.

In the largest sense, we are, ourselves, a cosmic phenomenon, ultimately born from some of the material and some of the same processes that shape the universe around us. In that regard, this course is also an introspection into the context, events, and history of our own existence. We study the universe not only to understand the universe itself as an external entity, but also to inform and enlarge our understanding of ourselves.

The primary conceptual aims of this course are: 1) to explore what scientific inquiry has revealed about the nature and history of the universe, and the processes that shape it; 2) to help you comprehend how the physical forces and the structure and behavior of matter shape the physical world; 3) to underscore how many of the same natural laws and phenomena that shape our everyday lives can be deployed to understand distant and exotic phenomena at great remove in space and time; and 4) to help you gain appreciation of how we know what we know, and why we are able to be confident in that knowledge, while, at the same time, being aware of the dynamic boundaries that separate confident knowledge from uncertainty and areas of still-persisting mystery.

Prerequisites

No special scientific or mathematical background beyond familiarity with basic high school physics, chemistry and algebra is assumed or needed for this course. Calculus will not be required, but we will occasionally engage rudimentary equations (algebra) and calculations. These will be designed to reinforce what you learn, and to help strengthen your skills in applying quantitative reasoning. Examples relevant to the homework will be worked through in class.

One of the animating motifs of this class is to help you learn how much you can understand on the basis of relatively simple ideas and concepts, without getting lost in a blizzard of details.

Learning Outcomes

The specific learning outcomes aimed at in this course focus on:

- Developing knowledge of basic scientific principles, and of how these principles are employed to advance and secure understanding of our world

- Advancing knowledge of the crucial roles played by observations, experiments and exploration in securing and understanding our world.
- Elucidating how the nature and behaviors of objects and systems throughout the universe are related to the underlying physical laws and properties of matter.
- Exploring the nature of light and how our understanding of the interactions of light and matter play such an important part in advancing our knowledge.
- Elucidating how we have been able to develop knowledge of the history and timescales of cosmic processes and events that produced -- and continue to sustain -- our surroundings.
- Exercising skill in the rudimentary application of basic mathematics (arithmetic) to understanding our world and phenomena around us.
- Developing an appreciation for the contingency and moving boundaries of knowledge, helping to perspective about the difference between what we know with high certitude, and what we do not know, and why.
- Becoming conversant with the greatest narrative that can ever be told: that of the nature and history of the Universe.

Course Textbook

The text for this course is:

> ***The Cosmic Perspective: Stars, Galaxies & Cosmology*** (9th or 8th edition is acceptable) by Bennett, Donahue, Schneider and Voit; Pearson (Addison-Wesley)

If you want the most up-to-date version, get the 9th edition. However, you will not be disadvantaged in this class by using the previous, 8th, edition, which you may be able find at a lower price. The textbook we are using is a subset of the more inclusive volume (***The Cosmic Perspective***) covering also the material for ASTR-102 (*Exploration of the Solar System*).

Class Website

Course materials including scores & grades, links to relevant websites, and supplementary material, as well as class updates and announcements will be posted on, ***or linkable from*****,** the Rice CANVAS webpage for this course. You are responsible for reading emails from the class website and checking the CANVAS course website regularly for up-to-date posted information. Homework assignments and tests will be distributed and collected through CANVAS.

Additional information and material of interest (including about scores on assignments and tests) may be posted on a separate course website, linkable both from the CANVAS course-site homepage or from a labeled button at the website: http://ehl.web.rice.edu.

Federal Title IX

Students are entitled to safe, supportive, equitable circumstances, free of harassment, gender or pregnancy discrimination, and free of relationship, sexual, or other forms interpersonal violence. If you find yourself in a violating situation, you are encouraged to seek support through the Rice SAFE Office. Under Federal Title IX regulations, most Rice employees, including me, are required to report any incident of non-consensual interpersonal behaviors that is disclosed to them. That report is to be made to campus Title IX professionals, who can intervene in support of the student.

For more information, visit https://safe.rice.edu or email titleixsupport@rice.edu.

Special Needs

Any student with a documented disability needing academic accommodation should speak with the instructor, preferably during the first two weeks of class. All such discussions are held confidential. Students with such disabilities will need to contact Disability Support Services: http://dss.rice.edu.

Adherence to Honor Code

The Rice Honor Code applies to all assignments and activities in this class. All students should be familiar with Honor Code and Council rules and procedures, which can be found at http://honor.rice.edu . Be aware that, under Rice rules, an instructor is afforded little discretion, and is required to report such suspicions to the Honor Council for independent disposition.

Homework &Tests

In addition to reading and study assignments from the textbook, there will be regular homework, and occasional tests. Homework assignments and tests will be distributed and collected through the CANVAS website.

Homework: Weekly homework assignments with questions and problems based on material covered or assigned during the previous week (or weeks) in the textbook or in class lectures. Homework assignments will be posted on CANVAS each Tuesday, and normally be due in class (or immediately before class if submitted online) the following Tuesday, unless otherwise specified in writing. For the homework, you may consult the textbook, your notes, and other materials, including the Web, unless otherwise indicated in writing. You may (and are encouraged to) work together to discuss general concepts and approaches before answering the questions, but the answers and work you submit must be entirely your own, based on your own understanding at the time you answer a question. Occasionally, for a homework question you may need to seek information available from the Web.

Late homework will normally not be accepted and will be scored zero. In computing the semester grade, each student's two lowest homework scores will automatically be discarded.

Tests: There will be two tests, one midterm test and one end-term test during the last week of class. the end-term test will focus on class material from the second half of the semester, covered since the first test; but you should keep in mind that, as in most science disciplines, the material is inherently cumulative, and material from the first part of the semester will be inherent in second-semester material. For both tests you may consult both the textbook and your own class notes. However, no other materials or sources, including web browsing, will be permitted: Each student is to complete the tests on her or his own, with no consultation. The tests will be similar to the homework in nature, except that each will cover a broader segment of the course and be pledged under the Rice Honor Code as your own independent work. The tests will be "take-home" tests.

There will be no separate final exam.

Attendance and Participation

Students should plan to attend class regularly. Those who do not are likely to find themselves at a significant disadvantage, inasmuch as, frequently, material will be covered in the lecture that is not be covered at similar completeness or depth in the book.

Grades

The grading rubric is based on the following:

- 50%.....Homework
- 50%.....Tests (25% each for mid-term and end-term)

The scale used in assigning final letter grades may be adjusted on the basis of outcomes rather than on a rigid, predefined scale. Every student who regularly and attentively attends class, and who attentively carries out the reading, study and homework assignments, should be able to achieve a fine grade.

Machines in the Classroom

Cell phones should be turned off -- or made silent -- within the classroom. (If you need to take an urgent call during class, please try to take it out of the room.) Laptops or other small devices may be used for class purposes such taking notes. Other uses (browsing, email, etc.) are distracting and disruptive; please be responsible and considerate using technology during class.

The Campus Observatory

From time to time, the Rice University Campus Observatory (https://physics.rice.edu/observatory) provides opportunity for hands-on observation of astronomical objects. Observing sessions are scheduled during the semester, and students are encouraged to take advantage of the opportunities offered by this excellent on-campus facility. Earth-based astronomical observing is contingent upon weather and local "seeing" conditions. Observing sessions may be organized or cancelled on unavoidably short notice. The nights for practical astronomy are associated with clear, cold weather conditions, so you are advised to dress appropriately.

Issues or Problems

If you experience issues, difficulties, or misunderstandings that affect you in this class, you are strongly encouraged to speak directly with the professor as soon as you can.

Syllabus Subject to Change

The information in this syllabus is subject to possible revision during the semester. If changes are made, enrolled students will be notified in a timely manner.

Explanations of the first-page header pictures [left to right]

- Spiral galaxy UGC 2885 - “Rubin’s Galaxy” (at a distance of 232 million light years from Earth): the late astronomer Vera Rubin conducted detailed studies of this galaxy, among others, in making her landmark, seminal contributions to the discovery of still-mysterious dark matter
- Crab Nebula supernova remnant: residuum from the violent explosion of a star, observed and documented by astronomers in China in the year 1054.
- Coronal Mass Ejection: explosive ejection of material out from the Sun’s atmosphere, driven by the energy released during explosive “reconnection” and bursting rearrangement of the Sun’s magnetic field above the Sun’s surface.
- Artist’s illustration of an accretion disk with an axial jet: a structure characteristic of a vast variety of astrophysical systems ranging from stars and planetary systems during the periods of their formation to distant quasars.
- Computed illustration of the distortions of the gravity field and of space-time around a pair of colliding and coalescing black holes as they produce a burst of gravitational radiation, carrying away some 5% of total mass-energy of the system in the form of “massless” gravity waves.